STUDY GUIDE

LIME SOFTENING

SUBCLASS L

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
BUREAU OF INTEGRATED SCIENCE SERVICES
P. O. BOX 7921
MADISON, WI 53707

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PREFACE

This operator's study guide represents the results of an ambitious program. Operators of wastewater and water supply facilities, regulators, educators and local officials, jointly prepared the objectives and exam questions for this subgrade.

The objectives in this study guide have been organized into modules, and within each module they are grouped by major concepts.

HOW TO USE THESE OBJECTIVES WITH REFERENCES

In preparation for the exams, you should:

1. Read all the objectives that apply to the grade level desired and write down the answers to the objectives that readily come to mind.

2. Use the references at the end of the study guide to look-up answers you don't know. This one set of references covers all of the objectives.

3. Write down the answers found in the references to those objectives you could not answer from memory.

4. Review all answered objectives until you can answer each from memory.

IT IS ADVISABLE THAT YOU ATTEND SOME FORM OF FORMAL TRAINING IN THIS PROCESS BEFORE ATTEMPTING THE CERTIFICATION EXAM.

Choosing A Test Date

Before you choose a test date, consider the training opportunities available in your area. A listing of training opportunities and exam dates can be found in the annual DNR "Certified Operator," or by contacting your DNR District operator certification coordinator.

LIME SOFTENING

MODULE A: PRINCIPLE, STRUCTURE AND FUNCTION

CONCEPT: PRINCIPLE OF LIME SOFTENING

1. Describe the lime softening process.
2. Define the term, "water hardness".
3. List the problems associated with hard water.
4. Identify two principle elements (cations) which cause hard water.
5. Identify additional elements which contribute to water hardness other than calcium and magnesium.
6. Explain how elements find their way into groundwater.
7. Differentiate between carbonate and non-carbonate hardness.

CONCEPT: STRUCTURE AND FUNCTION

8. Sketch a drawing of a typical lime softening facility; identifying processes and points of chemical addition in the appropriate order for each of the following:

   A. Straight Lime
   B. Split-lime
   C. Lime-soda Ash Split
   D. Lime-soda Ash
   E. Solids Contract Unit

9. Differentiate between gravimetric and volumetric dry feeders.
10. Describe the operation of a positive displacement pump.
11. On a sketch of a cross-section of a filter, label weirs, troughs, surface wash, media, underdrains, gravel.
12. Given a sketch of a filter showing valves, indicate which valve would be open or closed during filtering and backwashing.

MODULE B: OPERATION AND MAINTENANCE

CONCEPT: OPERATION

13. Define the following terms; raw eater, slaker, flocculation, coagulation, colloid, sedimentation, sludge blanket, clarifier, turbidity, recarbonation, finished water, sludge, and stabilization index.

14. Cite advantages and disadvantages of using lime softening to control water hardness.

15. Cite advantages and disadvantages of using lime softening for iron and manganese removal.

16. Differentiate between the terms, "feeding" and "mixing" and their relation to coagulation.

17. Differentiate between split lime treatment and excess lime treatment.

18. Describe the solids contact process.

19. State whether each of the following will increase, decrease or stay the same as a result of lime softening:

    A. Calcium Concentration
    B. Alkalinity Values
    C. Magnesium Concentrations
    D. Total Solids Values
    E. Hardness
    F. Iron Concentrations
    G. Manganese Concentrations
    H. Bacteria Levels
    I. Turbidity
    J. Sulfate Values
    K. Sodium Values
    L. Fluoride Levels
    M. Chloride Values

20. State the purpose of each of the following chemicals:

    A. Lime
    B. Alum
    C. Soda Ash
    D. Polymers
    E. Carbon Dioxide

21. Differentiate between quicklime and hydrated lime.

22. Differentiate between a primary coagulant and a coagulant aid.

23. Differentiate between anionic and cationic polymers.

24. Describe how polymer charge can affect coagulation.

25. Identify and describe situations where coagulant aids can help improve coagulation and flocculation.

26. Describe how the following situations affect coagulation.

    A. Temperature
    B. pH
    C. Concentration of Dissolved Solids
    D. Concentration of Suspended Solids
    E. Mixing Conditions
    F. Concentration of Coagulant

27. Identify factors affecting particle settling.

28. Describe the materials that can be used for filter media.

29. Explain the advantage multi-media filters have over sand filters.

30. Identify suitable rates in gpm/ft^2 for filtering and backwashing.

31. Describe the backwashing procedure.

32. Explain the benefits of expanding the bed during backwashing.

33. Identify the critical factors which must be considered in order to determine the duration of a backwash cycle.

CONCEPT: MAINTENANCE

34. Identify means to adjust chemical feed rates for the following:

    A. Gravimetric Feeder
    B. Volumetric Feeder
    C. Positive Displacement Pump

35. Describe the limiting factors which govern the rate of flow in a filter.

36. Identify means to prevent lime deposits on filter media.

37. Describe how to determine when to backwash a filter.

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MODULE C: MONITORING AND TROUBLESHOOTING

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CONCEPT: MONITORING

38. Identify the optimum pH for the precipitation of:

    A. Calcium Hardness
    B. Magnesium Hardness

39. Identify suitable ranges after treatment for each of the following:

    A. pH
    B. Alkalinity
    C. Hardness
    D. Turbidity

    NOTE: DNR and Williams Bay feel hardness should be 80-100 MG/L

40. Discuss various methods used to determine stability of water, including the Langelier Index method. How might a calcium carbonate solubility curve (ph vs. alkalinity) be used to determine the corrosive or depositing properties of a particular water?

41. Discuss laboratory tests used for process control in a lime softening facility.

42. State how often the tests listed above should be run.

43. Describe a jar test and list applications for use.

44. Define the following terms:

    A. End Point
    B. Phenolphthalein
    C. P-Alkalinity
    D. M-Alkalinity
    E. Acidic
    F. Basic
    G. NTU

45. State how many buffers should be used when calibrating a Ph meter.

46. Given approximate pH values, identify suitable buffers for use in calibrating a pH meter.

47. Identify the titrant in each of the following tests:

    A. Hardness
    B. Alkalinity

48. Cite advantages and disadvantages of liquid and powder indicators used in the EDTA hardness test.

49. Describe the color changes at the endpoints or P- and M-alkalinity tests.

50. Identify the pH values for the P-alkalinity and M-alkalinity endpoints.

CONCEPT: TROUBLESHOOTING

51. Given the following problems, pinpoint a cause and corrective action:

    A. Floc Going Over Weirs
    B. Corrosive Water
    C. High Turbidity
    D. Air Binding
    E. Media Loss
    F. Media Cracks

52. List suitable means of sludge disposal.

MODULE D: SAFETY AND CALCULATIONS

CONCEPT: SAFETY

53. Identify and describe protective measures used to store, transport and deliver alum and ferric chloride.

CONCEPT: CALCULATIONS

54. Given necessary data calculate:

    A. Rate of Flow Through a Filter
    B. Filter Backwash Rate
    C. Percent of Total Water Used For Backwashing

55. Given the necessary data formulas, calculate:

    A. Lime Dosage To Remove Carbonate Hardness
    B. Soda Ash Dosage To Remove Non-Carbonate Hardness
    C. Polymer Dosage in lbs/mg/L

56. Given pounds of lime used, gallons of water treated, raw and finished water hardness; calculate parts per million hardness removed per pound of lime.

57. Given the formula and laboratory data, calculate the hardness in ppm.

58. Given the formula and laboratory data, calculate the alkalinity in ppm.

59. Given P- and M-alkalinity values, use a table of alkalinity relationships to determine bicarbonate, carbonate and caustic alkalinity concentrations.

60. Given total and P-alkalinity data for either settled water or tap water determine what corrective action, if any, should be taken.

RESOURCES

1. **SMALL WATER SYSTEM OPERATION AND MAINTENANCE**. 1st Edition (1990). Kenneth D. Kerri. California State University, 6000 J Street, Sacramento, CA 95819-6025. Phone (916) 278-6142.

2. **STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER**. 17th Edition (1989), 18th Edition (1992). Joint Publication of: American Public Health Association; American Water Works Association; and, Water Environment Federation (Old WPCF). Publication Office: American Public Health Association, 1015 Fifteenth Street NW, Washington, DC 20005.

3. **WATER TREATMENT PLANT OPERATION**. 2nd Edition (1989). Volumes 1 and 2. Kenneth D. Kerri. California State University, 6000 J Street, Sacramento, CA 95819-6025. Phone (916) 278-6142.

4. **WISCONSIN ADMINISTRATIVE CODE NR 809 (OLD 109) SAFE DRINKING WATER**. Wisconsin Department of Natural Resources, Attn: Ken Cramer, P.O. Box 7921, Madison WI 53707.

5. **WISCONSIN ADMINISTRATIVE CODE NR 811 REQUIREMENTS FOR THE OPERATION AND DESIGN OF COMMUNITY WATER SYSTEMS**. Wisconsin Department of Natural Resources, Attn: Ken Cramer, P.O. Box 7921, Madison, WI 53707.

THE FOLLOWING ADDITIONAL RESOURCES CAN BE OBTAINED FROM:

AMERICAN WATER WORKS ASSOCIATION
MEMBER SERVICE DEPARTMENT
6666 W. QUINCY AVENUE
DENVER, CO 80235
(303)794-7711

1-800-92-ORDER (FOR CHARGE CARD CUSTOMERS OR AWWA MEMBERS ONLY)

6. **BASIC MANAGEMENT PRINCIPLES FOR SMALL WATER SYSTEMS**. AWWA No. 20222 (1982).

7. **BEFORE THE WELL RUNS DRY - VOLUMES I AND II**. VOLUME I, AWWA No. 20224 (1984). VOLUME II, AWWA No. 20225 (1984).

8. **DISINFECTION BY-PRODUCTS: CURRENT PERSPECTIVES**. AWWA No. 20032 (1989).

9. **MAINTENANCE MANAGEMENT**. James K. Jordan. AWWA No. 20252 (1990).

10. **NEW DIMENSIONS IN SAFE DRINKING WATER-SECOND EDITION**. AWWA No. 20235 (1988).

11. **PLAIN TALK ABOUT DRINKING WATER**. James M. Symons. AWWA No. 70076 (1991).

12. **PUBLIC INFORMATION - HOW TO BUILD A SUCCESSFUL PUBLIC INFORMATION/PUBLIC RELATIONS PROGRAM**. AWWA No. 20242 (1989).

13. **SAFE DRINKING WATER ACT SERIES**:

    SURFACE WATER TREATMENT RULE. AWWA No. 70055 (1990)
    PUBLIC NOTIFICATION. AWWA No. 70056 (1990)
    TOTAL COLIFORM RULE. AWWA No. 70057 (1990)
    VOC'S AND UNREGULATED CONTAMINANTS. AWWA No. 70058 (1990)
    LEAD AND COPPER. AWWA No. 70073) (1991)
    PHASE II: VOC'S,IOC'S, AND SOC'S. AWWA No. 70074 (1991)

14. **SLUDGE: HANDLING AND DISPOSAL**. AWWA No. 20034 (1989)

15. **TREATMENT TECHNIQUES FOR CONTROLLING TRIHALOMETHANE IN DRINKING WATER**. AWWA, No. 20221 (1982).

16. **WATER CONSERVATION**. William O. Maddaus. AWWA No. 20238 (1987)

17. **WATER QUALITY AND TREATMENT-FOURTH EDITION**. AWWA No. 10053 (1990).

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